PRODUCTION COST ISSUES FOR COSINE THETA AND COMMON COIL MAGNETS

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Vlhc MAGNET WORKSHOP

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Compare cosine theta, common coil:

processes

components

⇒ new ideas for cost-reduction r&d?

SUPERCONDUCTOR PROPERTIES	**NbTi**	**Nb3Sn or HTS (prereacted)**
Cost	Cheap	Expensive
Cable shape (precise)	Keystoned	Rectangular
Minimum bend radius	< 1 cm	~ 3 cm
Winding tension	Medium to high	Medium
Turn-to-turn insulation	Kapton – 1 mil delicate & robust to ~ 140 MPa	Glass cloth—delicate and robust
Apply turn-to-turn insulation	Barberpole wrap	Sock, weave, or barberpole wrap

Cost: New Nb_3Sn R&D effort (multilab, multivendor)
Separate copper stabilizer from superconducting wire
Bend radius: common coil magnets

COIL DESIGN	**Cosine Theta**	**Common Coil Racetrack**
Peak Field/Central Field	Highest	Similar in optimized design
Field Quality (systematic)	2D wedges, thick 3D end spacers	2D rectangles, thick 2D end spacers (+ auxiliary coils?)

Field quality: Start with large 2D coils.

Study tradeoffs:
complexity of auxiliary coils,
separate trim coils,
accelerator physics systematic f.q. tolerances

COIL MANUFACTURE	**Cosine Theta (3D)**	**Racetrack (2D)**
Coil Winder (automatic)	3D (rotates winding mandrel)	2D
Straight section (precise wedges)	Trapezoidal wedges	Rectangular wedges
Ends	Many 3D separators, inserted by hand	A few 2D separators
Leads	Solder to NbTi expansion loop	Different solder to NbTi expansion loop

COIL MFGR. (cont.)	**Cosine Theta (3D)**	**Racetrack (2D)**
Coil sizing fixture	3D 70 MPa precise heated complex insert	2D 0.1 MPa precise vacuum impreg. 2D insert
Conductor position random variation	~ 25 μm to 50 μm	Little data

** Common coil conductor position: make multiple (short) coils and magnets, nominally identical, measure field quality

COIL ASSEMBLY	**Cosine Theta**	**Common coil**
"Degree of difficulty"	6	3
Field Quality focus	Top-bottom coil matching	Left-right coil matching (little data)
Preload in straight section	Preload ≅ Lorentz force	Low appears to be ok
Axial preload	Thick endplates	Nominal

Field Quality: left-right matching calculations, trial assemblies

Preload: R&D fixturing that allows preload to be varied cheaply.

COIL ASSEMBLY (cont.)	**Cosine Theta**	**Common coil**
Assembly press	Massive, precise dimensions	Nominal (precise)
Coil contact parts (laminations)	Precise, complex collars (die cost)	Precise support plates (laminated?)
Ground plane insulation	Folded kapton	Kapton with many fewer folds

Coil contact parts:
laminated vs. nonlaminated designs for common coil.

YOKE (laminated)	**Cosine Theta**	**Common coil**
Shape	Approximately round interior, exterior	Racetrack interior, round or rectangular exterior
Amount of material	Lots, especially 1-in-1	Less
Configuration	1-in-1 vs 2-in-1	2-in-1